Gravatt, Dan

From: Kiefer, Robyn V NWK <Robyn.V.Kiefer@usace.army.mil>
Sent: Friday, September 05, 2014 12:16 PM
To: Gravatt, Dan; Field, Jeff; Peterson, Mary; Washburn, Ben
Cc: Donakowski, Joseph NWK; Hays, David C NWK; Leibbert, Jason M NWK; Young, Scott E NWK; Petersen, Michael MVS
Subject: Risk Presentation for CAG (UNCLASSIFIED)
Attachments: USACE Risk Presentation for CAG Meeting on 8 Sep 2014 .ppt; USACE Risk Presentation for CAG Meeting on 8 Sep 2014 .pdf

Classification: UNCLASSIFIED
Caveats: NONE

All:

See attached Risk presentation for Monday's CAG with edits incorporated. We will bring computer with presentation and will provide Ben with a copy of the presentation (in pdf format) on CD so you can provide it to the CAG, as you choose.

Per discussion, EPA will bring projector.

We'll see you on Monday at Drury Inn lobby around 5pm.

Safe travels!

Robyn Kiefer
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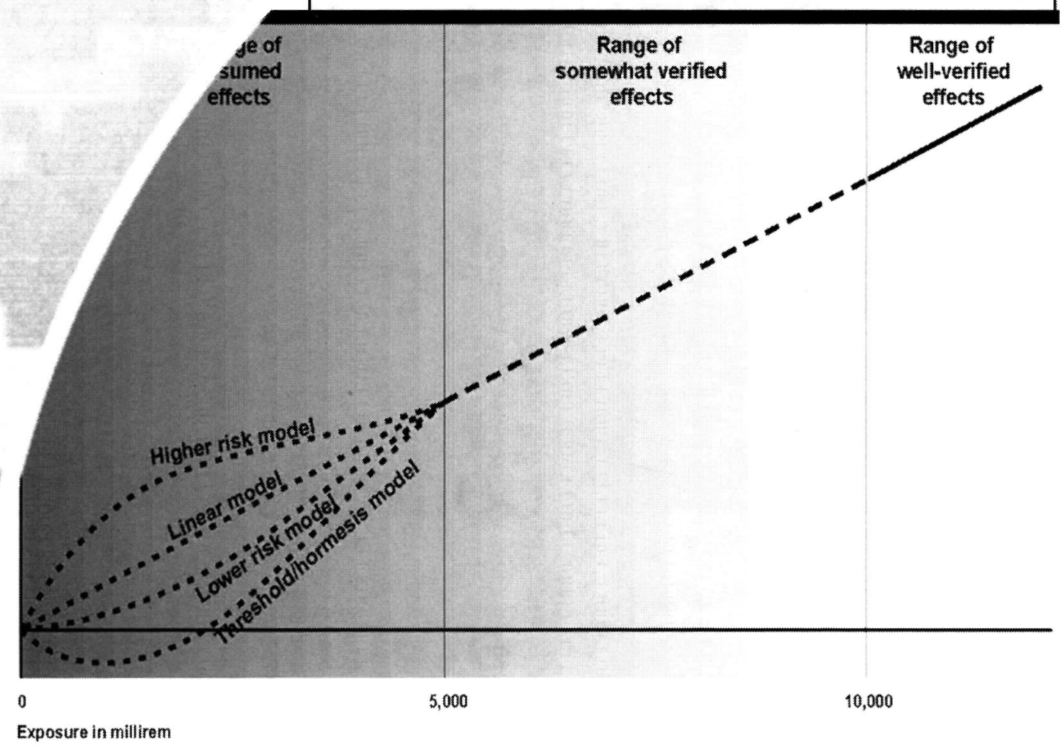
Radiation Risk in Perspective

USACE-NWK

8 September 2014



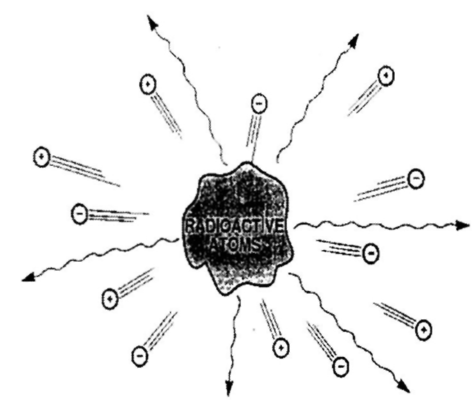
Discussion Outline

- What is a safe level of Radiation?
  - ► Radiation Basics
  - ► Dose vs. Risk Models
  - ► Regulatory Approach

- How is it determined if a site requires remediation?
  - ► Risk Assessments
  - ► How are Remediation Goals Determined
  - ► Preliminary Remediation Goals

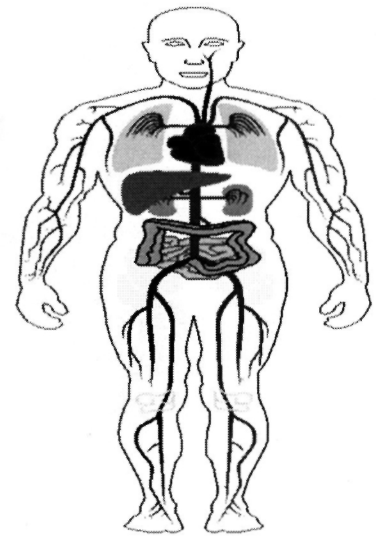
Radiation Basics

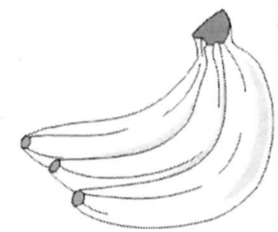
- **Radio"activity"** is the number of atoms decaying per time
  - For very low contaminated sites, units are picoCuries (pCi)
  - 1 pCi = 2.22 atoms decaying per minute
- Atoms decay by releasing energy and/or particles
  - When the particles hit us, energy is imparted
  - Results in exposure
- **Dose** is a measure of the impact of exposure
  - For very low contaminated sites units are millirems (mrem)
- **Risk** is a unit less value that expresses the chance of harmful effects resulting from exposure
  - At Superfund sites, risk is the chance that chemicals from a site will cause health and/or ecological problems.
- Dose relates to risk: generally, the higher the dose, the higher the risk



Radiation Sources

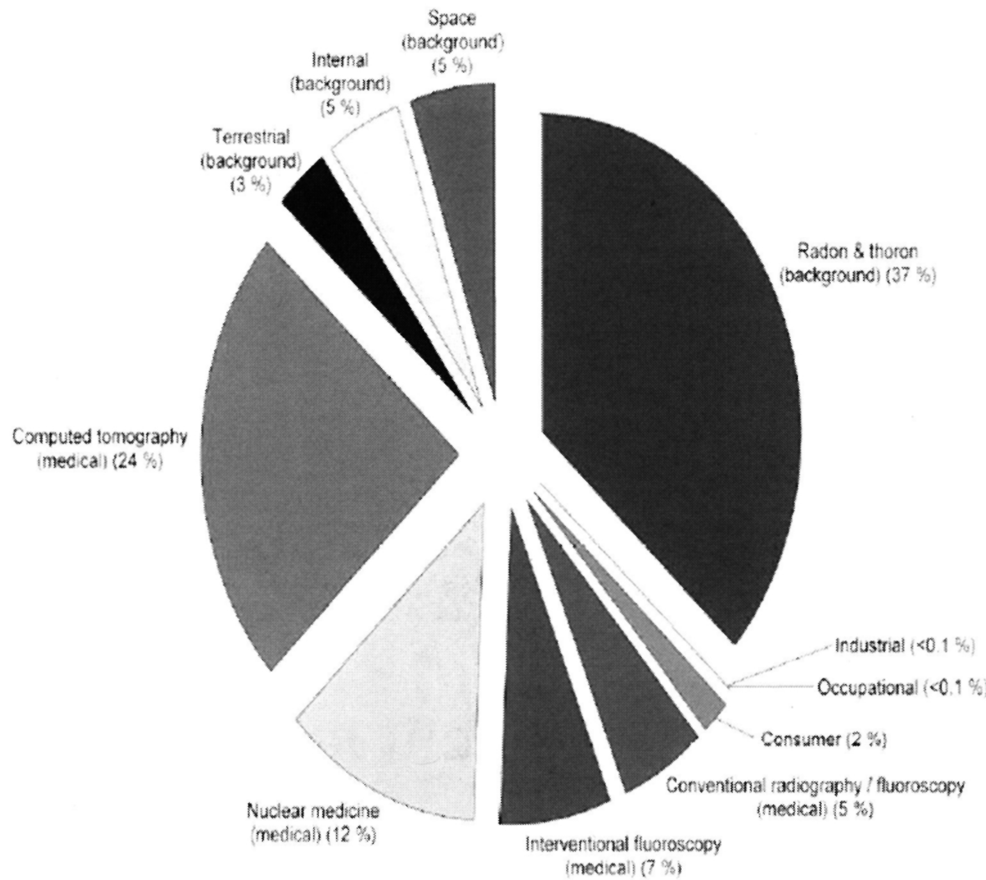
- Natural radiation is all around us
  - ► Cosmic photons and particles from the sun
  - ► Terrestrial materials in the earth's crust
  - ► Foods we eat
  - ► Internal in the body
  - ► In the air we breathe
  - ► In the water we drink
- Man made (non medical) radiation is a small fraction of our exposure





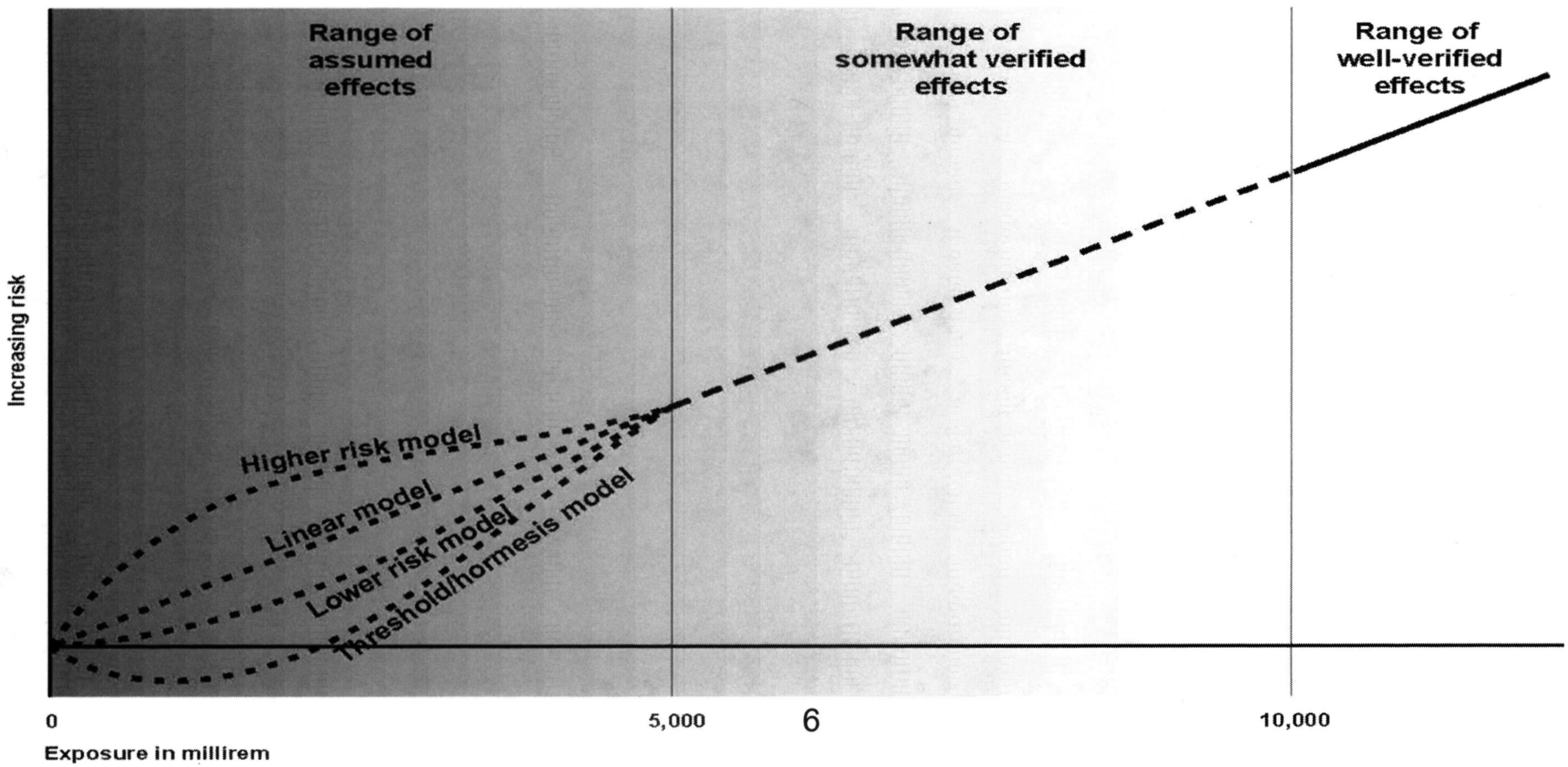
Radiation Exposure in the United States

- Everyone is exposed to radiation every day
- We are exposed to approximately 620 mrem per year
- Without medical dose, the average dose in St Louis area is approximately 340 mrem per yr



Dose to Risk Models

- We are exposed to radiation constantly, but what is safe?
- Several models estimate the dose to risk relationship
- Regulations are based on the linear model



Regulatory Approach

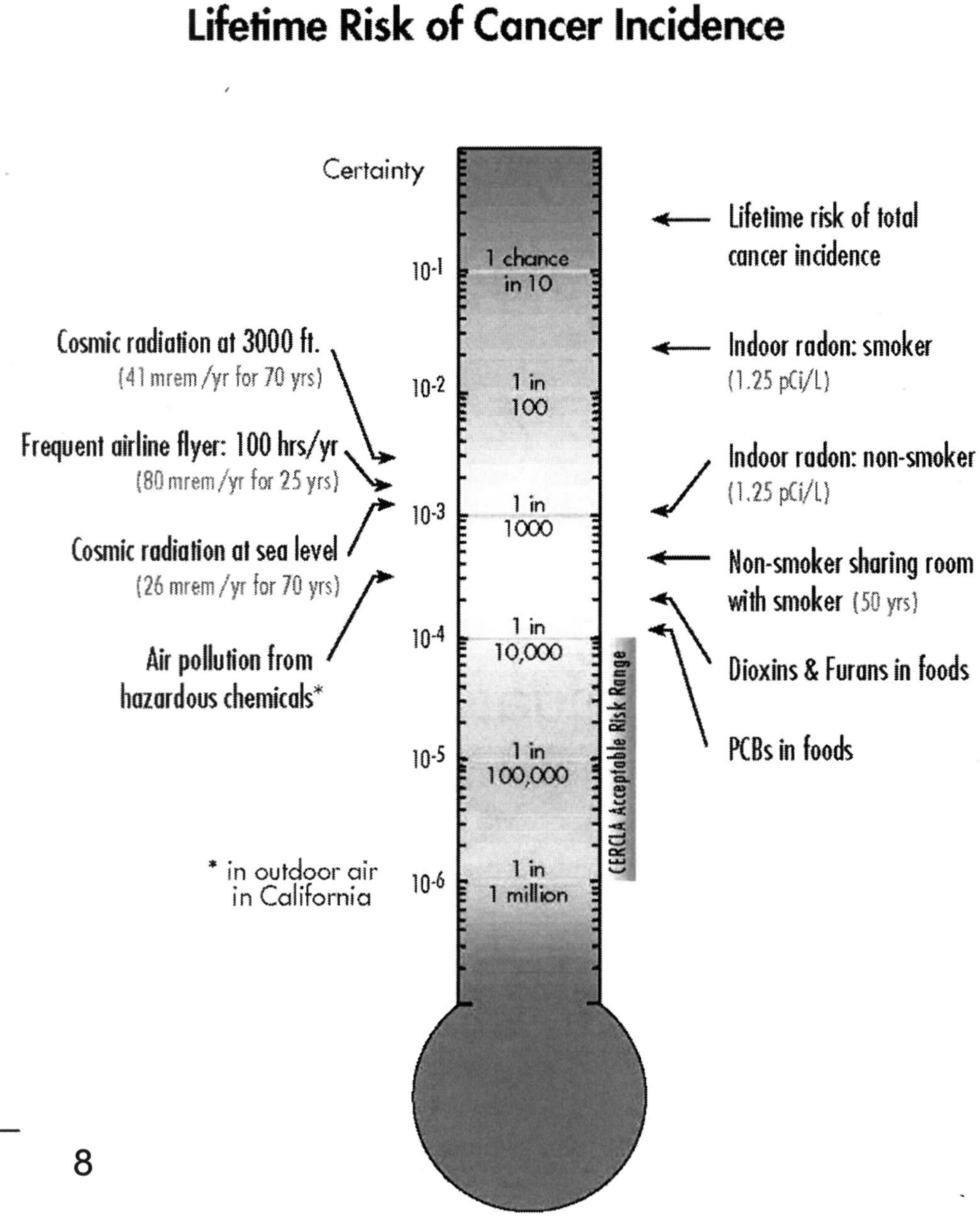
- The regulatory approach is based on the linear (no threshold) dose model
  - ▶ Conservative (likely overestimates risk)
  - ▶ Assumes a dose of radiation has the potential to cause an equivalent increase in risk

- EVERYTHING (driving, flying, smoking, etc.) carries some level of risk

- Regulations for hazardous waste sites refer to <u>acceptable risk</u>, not "safe" levels

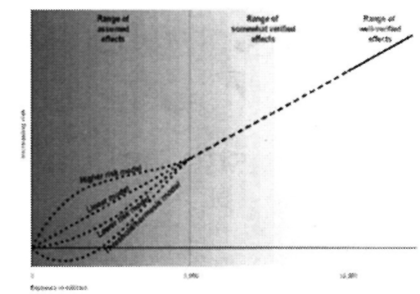
Regulatory Approach

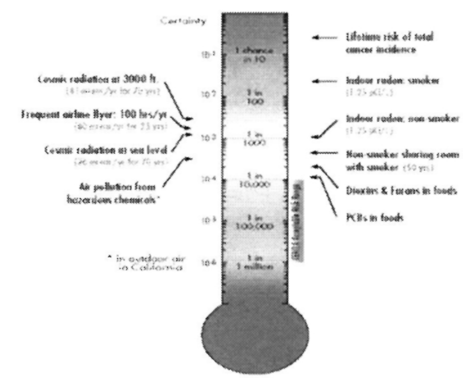
- 40 CFR 300.430(e) sets the acceptable risk range for hazardous and radioactive waste sites
  - ► Carcinogen (Radionuclides) Acceptable Risk Range: 1 in 10,000 to 1 in 1,000,000 lifetime increase in cancer risk (note: risk of getting cancer not risk of death)
  - ► Chance of getting cancer is now roughly 1 in 2 for males and 1 in 3 for females.
- Compare to risk of death:
  - ► Cancer 1 in 4(M) 5(F)
  - ► Driving (St. Louis) 1 in 10,000



Recap of Key Points

- Everyone is exposed to radiation every day
- Regulations are conservatively based to ensure safety
- Regulatory approach is to state in terms of "acceptable risk"
- Acceptable risk range: 1 in 10,000 to 1 in 1,000,000 additional cancer risk (also referred to as 1×10^{-4} to 1×10^{-6})





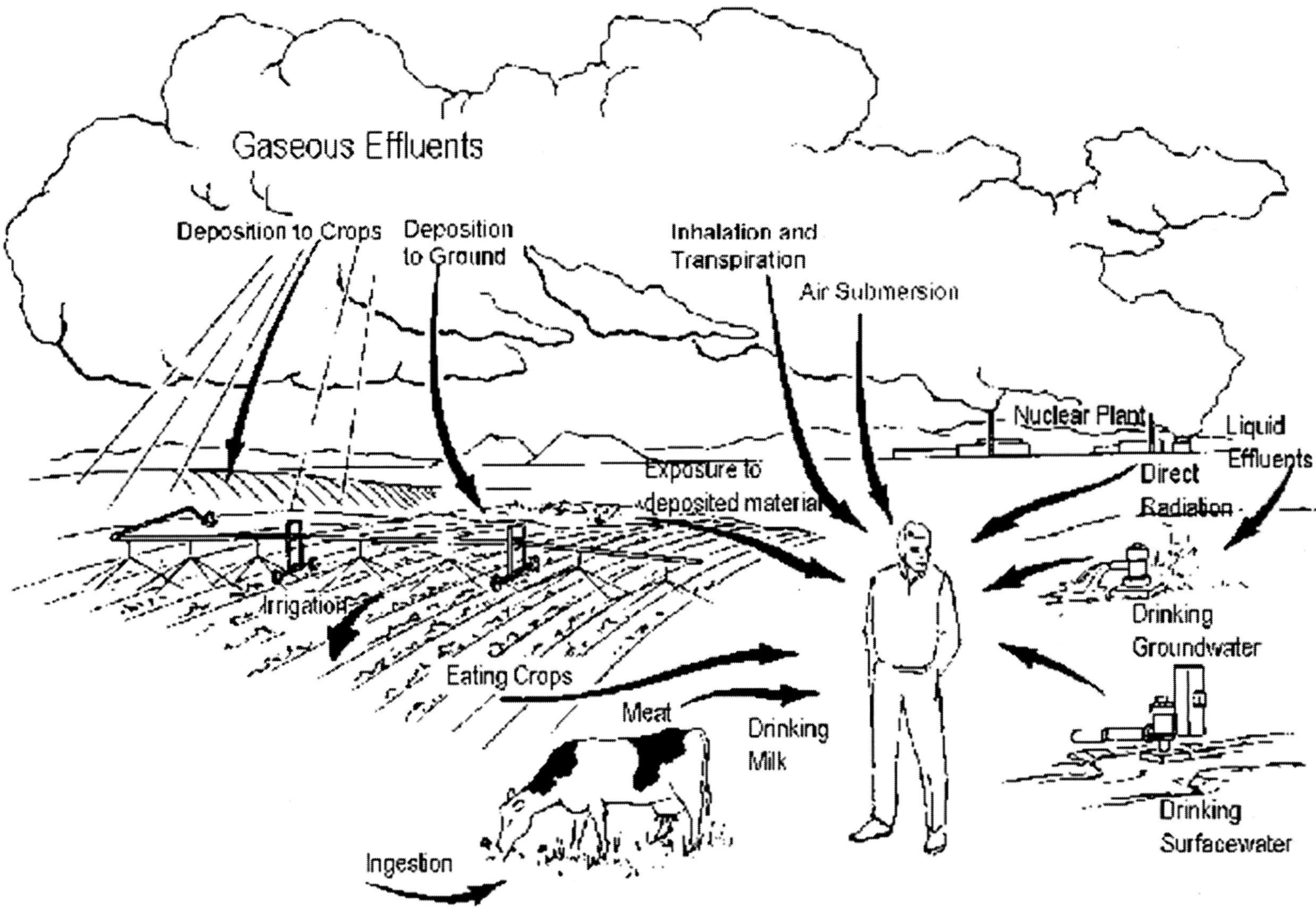
How is it Determined if a Site Requires Remediation?

- Hazardous waste regulations require a Health-Based Risk Assessment be performed and used to make decisions for addressing contamination at the site

- Risk Assessments:
  - Determine: Is there a risk? Who is at risk? How great is the risk? and What is causing the risk?
  - Evaluate all exposure scenarios:
    - Contaminants of concern (chemical and radiological)
    - Media of concern (soil, ground water, surface water, air, dusts, etc.)
    - Receptors (residents, workers, trespassers, ecological, etc.)
    - Exposure Pathways (drinking water, direct contact, ingestion, etc.)

- If risks exceed 1 in 10,000, action may be required
  - Engineering Controls
  - Land Use Controls
  - Remediation

Examples of Exposure Pathways



Determining Risk

- Only complete exposure pathways considered
  - ► If groundwater is not used (in impacted area), no complete pathway
  - ► If surface soils not contaminated, off-site exposure due to dust inhalation is not a concern
- All land uses are considered (current and future)
- Evaluate carcinogens and non-carcinogens (utilize hazard quotients for non cancer causing effects)
- Conservative assumptions are built in to the variables used in risk assessment calculations
  - ► Conservative assumptions in risk assessments tend to overestimate risk

Example Risk Assessment Exposure Scenario

- Current Conditions
  - Contaminants (Uranium, Thorium, Radium)
  - Media impacted (surface soils)
  - Site security, fenced
  - Land use controls (no residential, no use of ground water)
  - Lab data and modeling results indicate no off-site inhalation receptors
- Potential Receptors
  - Current: Groundskeeper, security staff, trespasser
  - Future: Groundskeeper, recreational user, trespasser, commercial user, construction worker, adjacent building user, outdoor storage worker
- Potentially Complete Exposure Pathways
  - Inhalation of fugitive dust and radon
  - Incidental ingestion of soil
  - Dermal contact with soil
  - External radiation exposure from contaminated soil

Example Risk Calculation

- For each receptor, chemical, and exposure pathway, risk calculations are performed
- Simplified example calculation for Cancer Risk due to inhalation:

$$C_{\text{exposure pt}} = C_{\text{Air}} \times (IR/BW) \times (ET \times EF \times ED) / AT$$

$$\text{Increased Cancer Risk} = IUR \times C_{\text{exposure pt}}$$

C=concentration (actual)
IR=inhalation rate (m3/hr)
ED=exposure duration (yrs)
EF=exposure frequency (d/yr)
AT=averaging time (d)
ET=exposure time (hr/d)
BW=body weight (kg)
IUR=Inhalation Unit Risk

- Complete all calculations, calculate the total risk for each receptor and pathway. Sum all calculated risks.
- If Total Cancer Risk > 1×10^{-4}, action may be required

West Lake

- Baseline Risk Assessment conducted in 2000 (OU1 Area 1, Area 2, Ford Property)
  - ▶ Carcinogens (including radionuclides & daughters)
  - ▶ Non Carcinogens
  - ▶ 1000 year study period, includes decay & in-growth
  - ▶ Per Risk Assessment Report
    - No exposure to off site receptors
    - Future risk for groundskeeper and outside storage worker exposures exceeded 1 in 10,000 risk

- Risk to be addressed through remedy

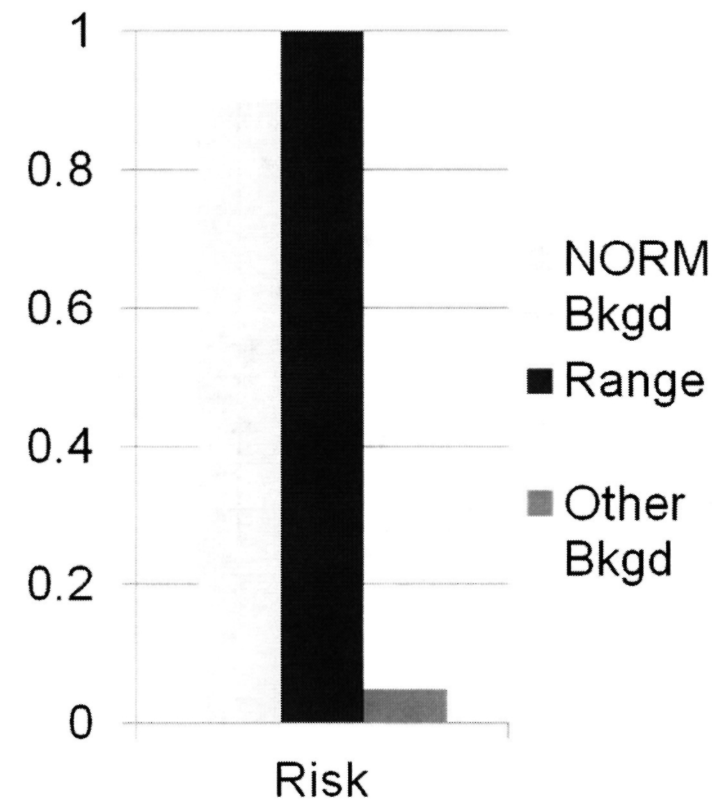
How are Remediation Goals Determined?

- Remediation Goals (RG) are sometimes referred to as clean up level, remedial action criteria, etc.
- RGs are primarily determined based on regulation or risk
  - Regulation may set acceptable RG level (may not be based on risk)
    - RGs set by regulations are considered protective
    - Examples: Maximum Contaminant Levels for drinking water and UMTRCA
  - Risk-based RGs are established to result in a target risk within the CERCLA risk range
- RGs are contaminant and media specific concentrations that demonstrate compliance with remedial action objectives

Impact of Background Levels on RGs

- When a contaminant is not present in background or is present at a low level, background may not need to be considered

- For the naturally occurring radioactive material (NORM), background concentration risks are often significant compared to the acceptable risk range, thus the RG is almost always expressed as in excess of background
  - Example: 5 pCi/g above background



Impact of Levels Background on RGs

- Although often presented as a single value, Background varies and is a range. It should not be thought of as a single value.

Nation	U238 (pCi/g)		Ra226 (pCi/g)		Th232 (pCi/g)	
	Mean	Typical Range	Mean	Typical Range	Mean	Typical Range
United States	0.9	0.1 - 3.8	1.1	0.2 - 4.3	0.9	0.1 - 3.5
Missouri	1.1	0.3 - 1.7	1.1	0.3 - 1.4	1.0	0.3 - 1.3
Ohio	1.4	0.8 – 2.2	1.5	0.8 – 2.5	1.0	0.7 – 1.5
Russia	0.5	0 - 1.8	0.7	0 - 2.1	0.8	0.1 - 2.1
Greece	0.7	0 - 6.5	0.7	0 - 6.5	0.6	0 - 5.1
West Lake	1.3	0.74-1.85	1.1	0.95-1.19	0.9	0.52-1.26

Different Sites Can Have Different RGs

- This is due to factors that impact how the RGs are determined:
  - ► Regulatory authority
  - ► Radiation standards / ARARs
  - ► Health assessment approaches
  - ► Land uses / exposure scenarios
  - ► Input parameters
  - ► Physical settings

West Lake

- West Lake Background (mean ± 2σ):
  - Ra-226 1.06 ± 0.24 pCi/g = 1.30 pCi/g (Missouri mean ± 2σ: 1.7 pCi/g)
  - Th-232 0.9 ± 0.66 pCi/g = 1.56 pCi/g (Missouri mean ± 2σ: 1.6 pCi/g)
  - Ra-226 + Th-232 = 2.86 ≈ 2.9 pCi/g (Missouri Ra+Th = 3.3 pCi/g)

- Remediation Goal:
  - ARAR UMTRCA: 5 pCi/g + Background (Ra226, Th232)
  - UMTRCA goal is for residential use*
  - Background (95% UCL): 2.9 pCi/g
  - Derived Remediation Goal*: Ra-226 & Th-232: 7.9 pCi/g

* Use of UMTRCA residential remediation goal is conservative for West Lake, given land use restrictions that prevent residential use

What are Preliminary Remediation Goals (PRGs)?

- PRGs are used when first investigating a site to determine if additional investigation is needed (BMAC)

- Very conservative screening levels

- Follow the CERCLA acceptable risk range of excess cancer incidence rate of 1 in 1,000,000

Relative Risks for Comparison

- For comparison, some other lifetime risk factors
  - Death from heart disease ~ 1 in 6
  - Death from falls ~ 1 in 160
  - Death from storms ~ 1 in 30,000
  - Death from earthquake or landslide ~ 1 in 100,000
  - Death from lightning ~ 1 in 130,000
  - Death from food poisoning ~ 1 in 600,000
  - Death from accidental fireworks discharge ~ 1 in 650,000

* Source = National Center for Health Statistics 2008 Mortality Data

PRGs vs. RGs

PRGs

- Preliminary, not final
- Contaminant and media specific
- Risk based (generic scenarios)
- Usually do not consider
  - Site specifics
  - Technical Feasibility
  - Schedule
  - Resources
  - Costs
  - Regulations
  - Background
- Used as screening
- Very Conservative

RGs

- Final Remediation Goal
- Contaminant and media specific
- Must consider
  - Site Specifics
  - Technical Feasibility
  - Resources
  - Regulations (may not be risk based)
  - Risk
- Used to determine if site meets remedial action objectives

Summary

- Remediation Goals
  - ► Risk-based (site-specific calculations) or ARARs (regulations)
  - ► Remediation goals will be different from site to site
  - ► Background impacts
    - Background levels are ranges, not a single number
    - Vary from site to site

- Preliminary Remediation Goals
  - ► Screening only, used to determine if additional investigation is required
  - ► Intended to be very conservative

Summary

- What is a safe level of Radiation?
  - ► Radiation exposure occurs every day
  - ► Regulations conservatively based on assumption that any exposure to radiation results in some risk
  - ► Regulatory approach is to state in terms of "acceptable risk"
  - ► 1 in 10,000 chance of increased cancer risk is considered acceptable

- How is it determined if a site requires remediation?
  - ► Risk Assessment - who is exposed, what they are exposed to, how much they are exposed to, & how they are exposed
  - ► Risk Assessment results > 1 in 10,000 may require action

Questions?

DOE MO Background Study

Table 19. Background radiation levels and nuclide concentrations in surface soil samples in the State of Missouri

Sample designation	Description of sample location	Average external gamma exposure rate ($\mu R/h$)[a]	Nuclide concentration in surface soil (pCi/g)[b]		
			^{226}Ra	^{232}Th	^{238}U
MO-1	Approx. 45 km E of Kansas City, Missouri, in pasture field on S side of I-70	6.0	1.4 ± 0.04	1.3 ± 0.10	1.7
MO-2	Approx. 140 km E of Kansas City, Missouri, at intersection of I-70 and exit J, SE corner	10	1.3 ± 0.06	1.2 ± 0.10	1.3
MO-3	Rest stop on S side of I-70, ~16 km E of Williamsburg, Missouri	6.7	1.1 ± 0.06	1.0 ± 0.08	1.2
MO-4	SE corner of intersection of Hwy 175 and I-70 in O'Fallon, Missouri	7.5	1.3 ± 0.08	1.1 ± 0.12	1.1
MO-5	Approx. 34 km N of Missouri-Arkansas border, on E side of I-55, mile marker 21	8.1	1.2 ± 0.04	1.2 ± 0.06	1.3
MO-6	E side of I-55, ~14 km N of intersection with Hwy Alt. 61, at mile marker 76	5.4	0.31 ± 0.04	0.32 ± 0.04	0.33
MO-7	E side of I-55, ~1.6 km S of Appleton exit, E of Friedheim, Missouri	7.6	1.1 ± 0.06	1.1 ± 0.06	1.1
MO-8	Exit O off I-55, near Bloomsdale, Missouri	6.8	0.83 ± 0.04	0.76 ± 0.06	0.81
MO-9	E side of I-55, ~0.4 km S of Hwy 141 intersection, Maxville, Missouri	5.1	1.1 ± 0.06	1.1 ± 0.06	1.1
MO-10	W side of Hwy 367, ~0.3 km S of intersection with Hwy 67, N of St. Louis, Missouri	4.6	1.0 ± 0.10	0.95 ± 0.14	0.76

[a]Exposure rate determined from 3 to 4 measurements at each location using a "Phil" tube as described in Appendix I.

[b]Standard deviation of ^{226}Ra and ^{232}Th measurements are given as the 2σ value. Error in the ^{238}U measurements are $\leq 5\%$ (2σ).

DOE MO Background Study

Sample	gamma exposure rate	Ra226	Th232	U238
MO-1	6.0	1.4	1.3	1.7
MO-2	10.0	1.3	1.2	1.3
MO-3	6.7	1.1	1.0	1.2
MO-4	7.5	1.3	1.1	1.1
MO-5	8.1	1.2	1.2	1.3
MO-6	5.4	0.3	0.3	0.3
MO-7	7.6	1.1	1.1	1.1
MO-8	6.8	0.8	0.8	0.8
MO-9	5.1	1.1	1.1	1.1
MO-10	4.6	1.0	1.0	0.8
Min	**4.6**	**0.3**	**0.3**	**0.3**
Median	**6.8**	**1.1**	**1.1**	**1.1**
Mean	**6.8**	**1.1**	**1.0**	**1.1**
Max	**10.0**	**1.4**	**1.3**	**1.7**
Standard Deviation	**1.6**	**0.3**	**0.3**	**0.4**
Mean + 2 SD	**10.0**	**1.7**	**1.6**	**1.8**

Radioactivity in Common Materials

Building Materials	Ra-226 (pCi/g)	Th-232 (pCi/g)	K-40 (pCi/g)
Concrete	0.0 - 7.5	0.0 - 5.7	0.2 - 47.1
Aerated concrete	0.3 - 25.0	0.0 - 6.6	5.4 - 48.0
Clay bricks	0.0 - 6.0	0.0 - 6.0	1.8 - 60.0
Sand-lime bricks and sandstone	1.0 - 12.0	0.3 - 28.8	0.2 - 21.0
Natural building stones	0.0 - 15.0	0.0 - 9.3	2.3 - 210.3
Natural gypsum	0.0 - 2.0	0.0 - 3.0	0.2 - 8.4
Cement	0.2 - 6.0	0.2 - 7.0	0.7 - 25.5
Tiles	1.0 - 6.0	0.6 - 6.0	4.8 - 42.3
Phosphogypsum	0.0 - 21.0	0.6 - 10.8	0.8 - 3.6
Blast furnace slag stone and cement	1.0 - 4.0	0.9 - 6.6	-
Fertilizers	**U-238 (pCi/g)**	**Ra-226 (pCi/g)**	**Th-232 (pCi/g)**
PK fertilizer	12.3	11.1	0.5
NP fertilizer	27.6	9.3	0.9
NPK fertilizer	13.2 - 14.1	6.3 - 8.1	0.5
NORM in Coal Ash	**Total Ra (pCi/g)**	**Total Th (pCi/g)**	
Hungarian Coal	6.0 - 60.0	0.6 - 9.0	
USA Coal	3.0 - 18.0	0.9 - 9.0	
German Coal	2.0 - 7.4	2.3 - 5.1	

Background Variability

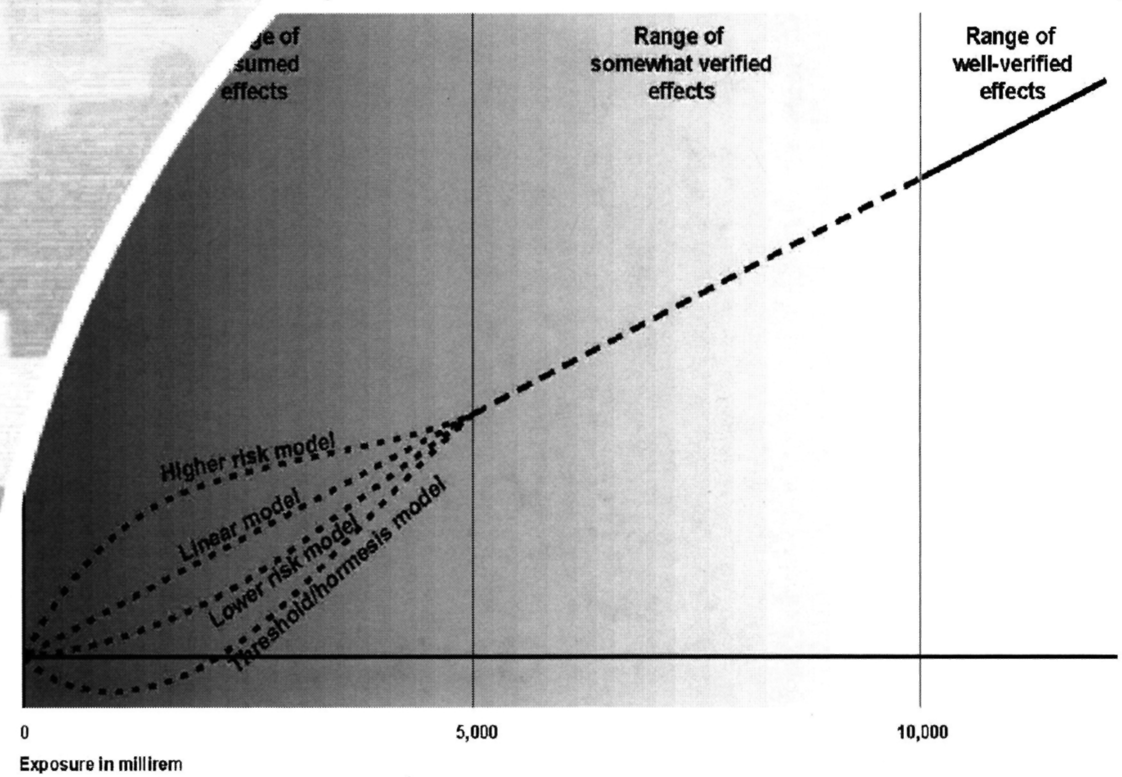
City	Millirads per 30 years	City	Millirads per 30 years
Harrisburg, Pa.	2640	Denver, Colo.	4410
Pittsburgh, Pa.	2880	Colorado Springs, Colo.	5040
Cleveland, O.	2730	Grand Junction, Colo.	4140
Toledo, O.	2280	Albuquerque, N.M.	3480
Chicago, Ill.	2640	Amarillo, Tex.	3240
Madison, Wis.	2520	Oklahoma City, Okla.	2520
Minneapolis, Minn.	2760	Tulsa, Okla.	2760
Sioux Falls, S.D.	2850	Little Rock, Ark.	3180
Cheyenne, Wyo.	4260	Memphis, Tenn.	2850

Table 1-2. Background radiation levels (including cosmic radiation) in millirads per 30 years, in some cities of the United States.

Radiation Risk in Perspective

USACE-NWK

8 September 2014



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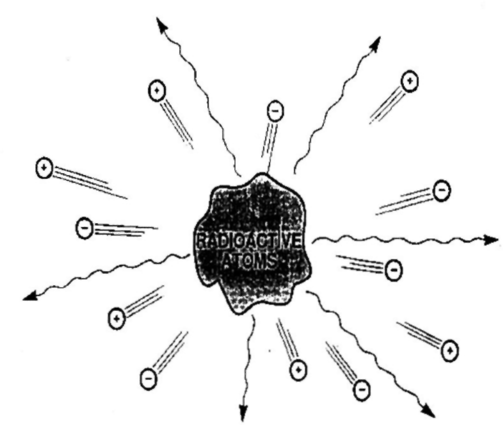
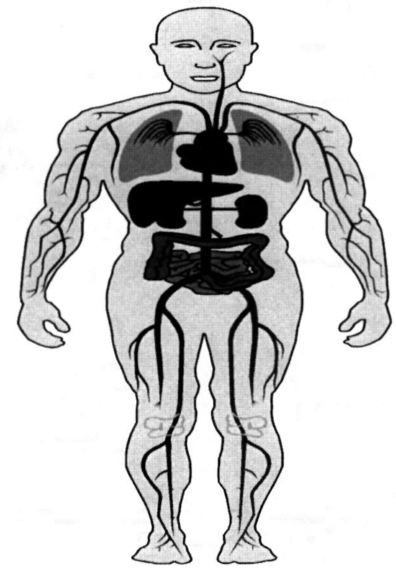
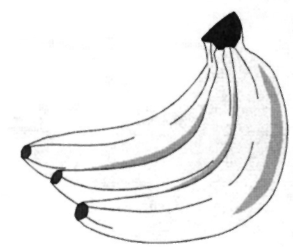
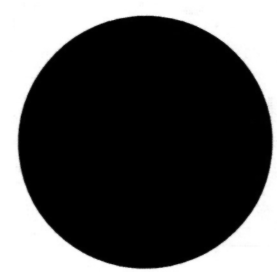


Radiation Sources

- Natural radiation is all around us
  - Cosmic photons and particles from the sun
  - Terrestrial materials in the earth's crust
  - Foods we eat
  - Internal in the body
  - In the air we breathe
  - In the water we drink
- Man made (non medical) radiation is a small fraction of our exposure







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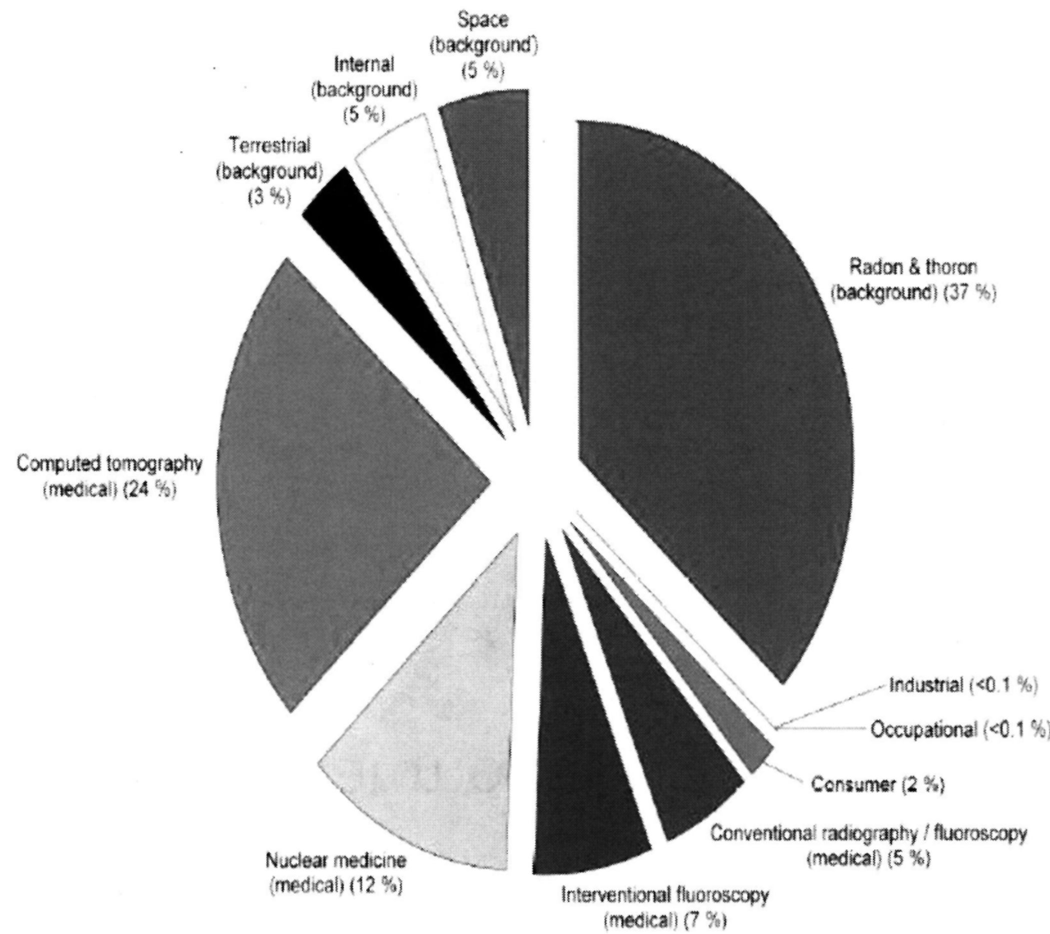

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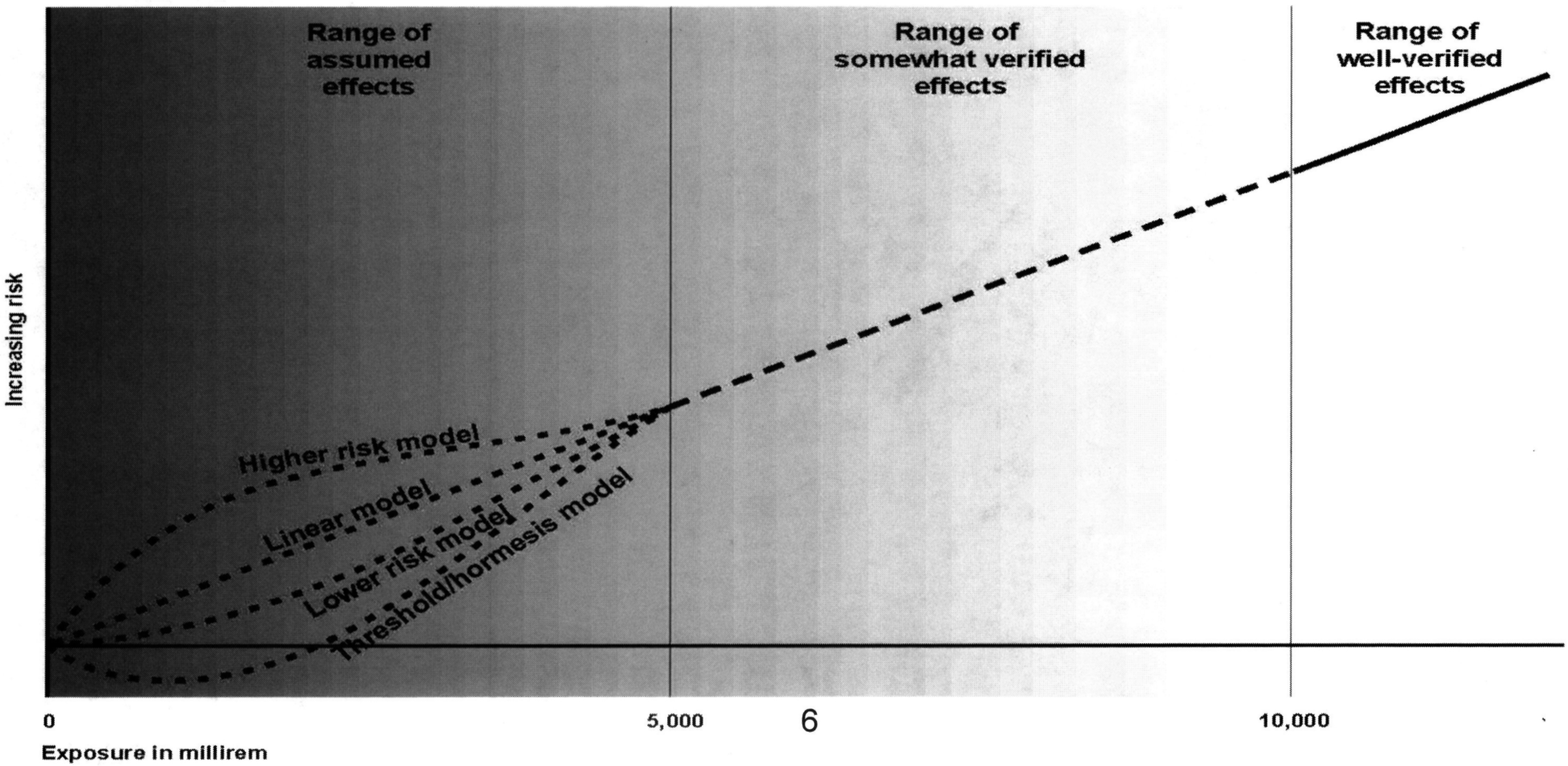

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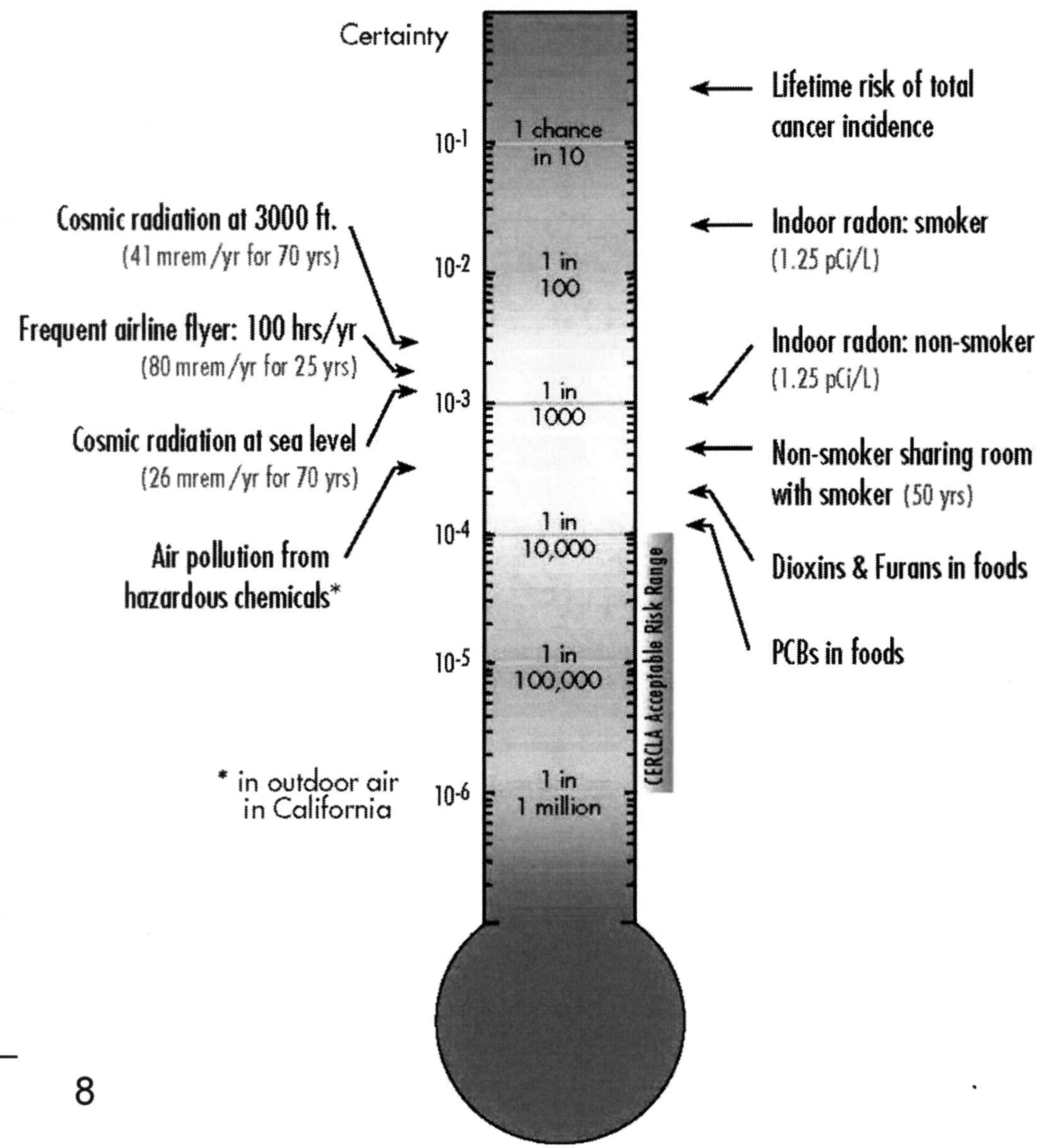
  - ► Chance of getting cancer is now roughly 1 in 2 for males and 1 in 3 for females.
- Compare to risk of death:
  - ► Cancer 1 in 4(M) 5(F)
  - ► Driving (St. Louis) 1 in 10,000

Lifetime Risk of Cancer Incidence



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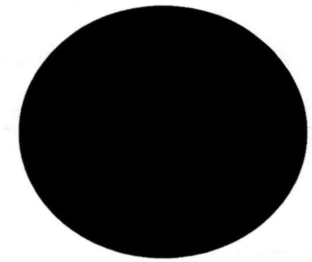
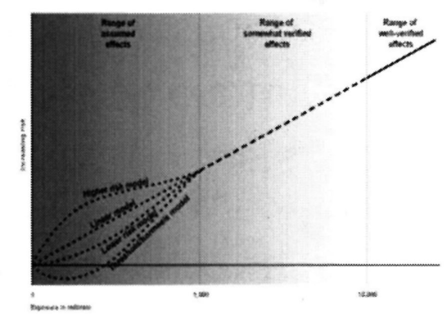
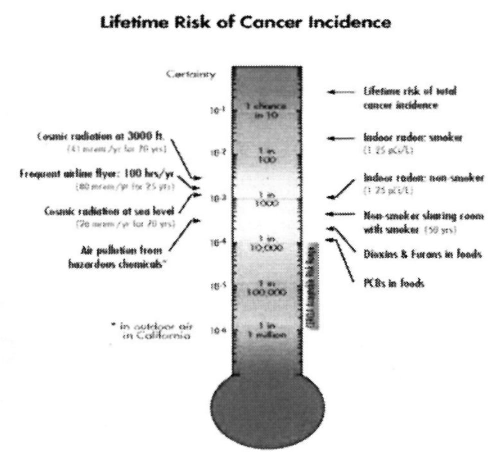
- Regulations are conservatively based to ensure safety
- Regulatory approach is to state in terms of “acceptable risk”
- Acceptable risk range: 1 in 10,000 to 1 in 1,000,000 additional cancer risk (also referred to as $1x10^{-4}$ to $1x10^{-6}$)







BUILDING STRONG®

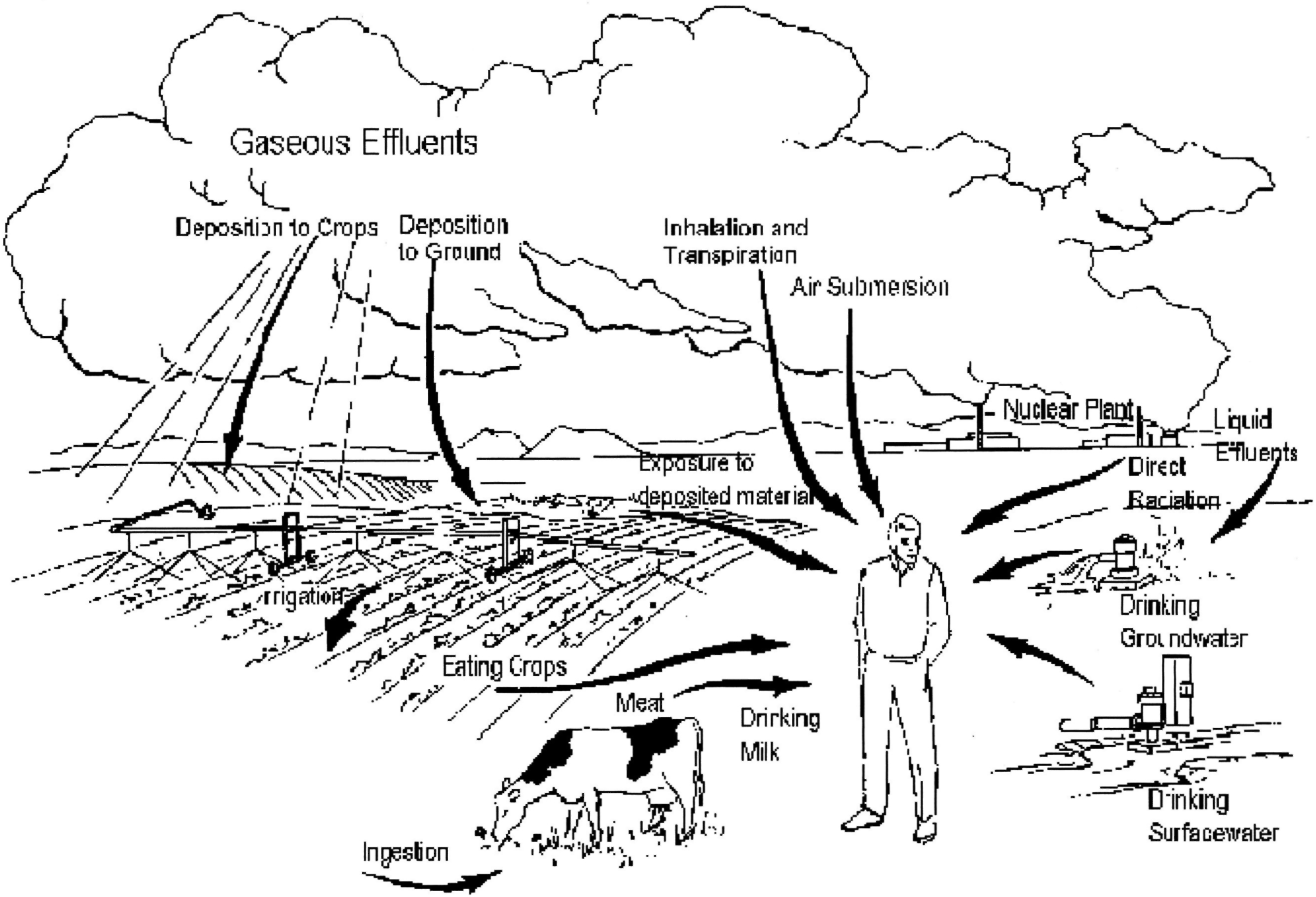
How is it Determined if a Site Requires Remediation?

- Hazardous waste regulations require a Health-Based Risk Assessment be performed and used to make decisions for addressing contamination at the site

- Risk Assessments:
  - Determine: Is there a risk? Who is at risk? How great is the risk? and What is causing the risk?
  - Evaluate all exposure scenarios:
    - Contaminants of concern (chemical and radiological)
    - Media of concern (soil, ground water, surface water, air, dusts, etc.)
    - Receptors (residents, workers, trespassers, ecological, etc.)
    - Exposure Pathways (drinking water, direct contact, ingestion, etc.)

- If risks exceed 1 in 10,000, action may be required
  - Engineering Controls
  - Land Use Controls
  - Remediation

Examples of Exposure Pathways



Determining Risk

- Only <u>complete</u> exposure pathways considered
  - ► If groundwater is not used (in impacted area), no complete pathway
  - ► If surface soils not contaminated, off-site exposure due to dust inhalation is not a concern
- All land uses are considered (current and future)
- Evaluate carcinogens and non-carcinogens (utilize hazard quotients for non cancer causing effects)
- Conservative assumptions are built in to the variables used in risk assessment calculations
  - ► Conservative assumptions in risk assessments tend to overestimate risk

Example Risk Assessment Exposure Scenario

- Current Conditions
  - Contaminants (Uranium, Thorium, Radium)
  - Media impacted (surface soils)
  - Site security, fenced
  - Land use controls (no residential, no use of ground water)
  - Lab data and modeling results indicate no off-site inhalation receptors
- Potential Receptors
  - Current: Groundskeeper, security staff, trespasser
  - Future: Groundskeeper, recreational user, trespasser, commercial user, construction worker, adjacent building user, outdoor storage worker
- Potentially Complete Exposure Pathways
  - Inhalation of fugitive dust and radon
  - Incidental ingestion of soil
  - Dermal contact with soil
  - External radiation exposure from contaminated soil

Example Risk Calculation

- For each receptor, chemical, and exposure pathway, risk calculations are performed

- Simplified example calculation for Cancer Risk due to inhalation:

$$C_{exposure\ pt} = C_{Air} \times (IR/BW) \times (ET \times EF \times ED) / AT$$

$$\text{Increased Cancer Risk} = IUR \times C_{exposure\ pt}$$

C=concentration (actual)	AT=averaging time (d)
IR=inhalation rate (m3/hr)	ET=exposure time (hr/d)
ED=exposure duration (yrs)	BW=body weight (kg)
EF=exposure frequency (d/yr)	IUR=Inhalation Unit Risk

- Complete all calculations, calculate the total risk for each receptor and pathway. Sum all calculated risks.

- If Total Cancer Risk > 1×10^{-4}, action may be required

West Lake

- Baseline Risk Assessment conducted in 2000 (OU1 Area 1, Area 2, Ford Property)
  - ► Carcinogens (including radionuclides & daughters)
  - ► Non Carcinogens
  - ► 1000 year study period, includes decay & in-growth
  - ► Per Risk Assessment Report
    - No exposure to off site receptors
    - Future risk for groundskeeper and outside storage worker exposures exceeded 1 in 10,000 risk

- Risk to be addressed through remedy

How are Remediation Goals Determined?

- Remediation Goals (RG) are sometimes referred to as clean up level, remedial action criteria, etc.

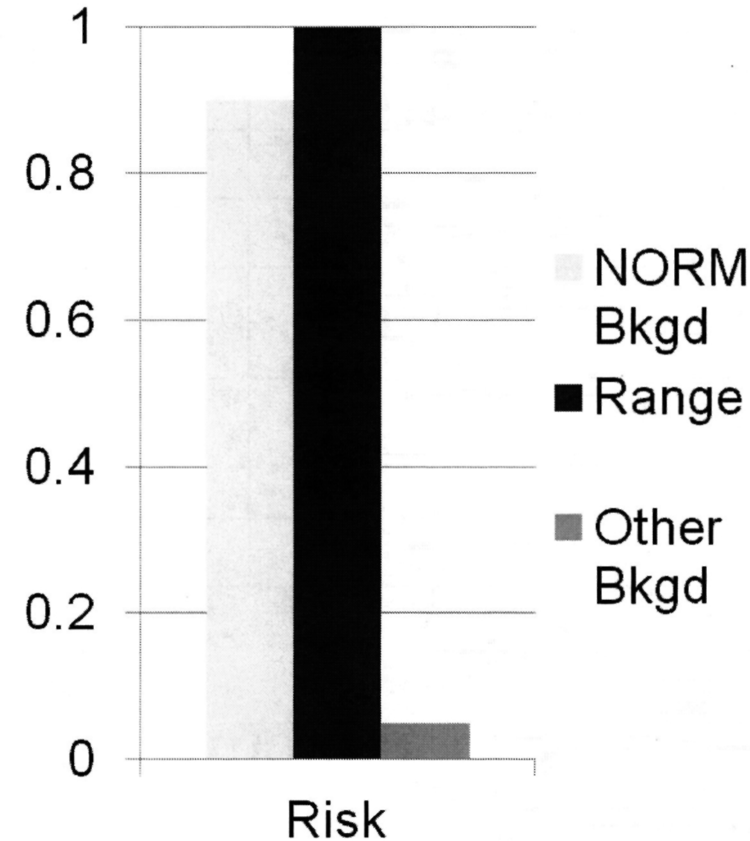
- RGs are primarily determined based on regulation or risk
  - Regulation may set acceptable RG level (may not be based on risk)
    - RGs set by regulations are considered protective
    - Examples: Maximum Contaminant Levels for drinking water and UMTRCA
  - Risk-based RGs are established to result in a target risk within the CERCLA risk range

- RGs are contaminant and media specific concentrations that demonstrate compliance with remedial action objectives

Impact of Background Levels on RGs

- When a contaminant is not present in background or is present at a low level, background may not need to be considered

- For the naturally occurring radioactive material (NORM), background concentration risks are often significant compared to the acceptable risk range, thus the RG is almost always expressed as in excess of background
  - Example: 5 pCi/g above background



Impact of Levels Background on RGs

- Although often presented as a single value, Background varies and is a range. It should not be thought of as a single value.

Nation	U238 (pCi/g)		Ra226 (pCi/g)		Th232 (pCi/g)	
	Mean	Typical Range	Mean	Typical Range	Mean	Typical Range
United States	0.9	0.1 - 3.8	1.1	0.2 - 4.3	0.9	0.1 - 3.5
Missouri	1.1	0.3 - 1.7	1.1	0.3 - 1.4	1.0	0.3 - 1.3
Ohio	1.4	0.8 – 2.2	1.5	0.8 – 2.5	1.0	0.7 – 1.5
Russia	0.5	0 - 1.8	0.7	0 - 2.1	0.8	0.1 - 2.1
Greece	0.7	0 - 6.5	0.7	0 - 6.5	0.6	0 - 5.1
West Lake	1.3	0.74-1.85	1.1	0.95-1.19	0.9	0.52-1.26

Different Sites Can Have Different RGs

- This is due to factors that impact how the RGs are determined:
  - Regulatory authority
  - Radiation standards / ARARs
  - Health assessment approaches
  - Land uses / exposure scenarios
  - Input parameters
  - Physical settings

West Lake

- West Lake Background (mean $\pm 2\sigma$):
  - ▶ Ra-226 1.06 ± 0.24 pCi/g = 1.30 pCi/g (Missouri mean $\pm 2\sigma$: 1.7 pCi/g)
  - ▶ Th-232 0.9 ± 0.66 pCi/g = 1.56 pCi/g (Missouri mean $\pm 2\sigma$: 1.6 pCi/g)
  - ▶ Ra-226 + Th-232 = 2.86 ≈ 2.9 pCi/g (Missouri Ra+Th = 3.3 pCi/g)

- Remediation Goal:
  - ▶ ARAR UMTRCA: 5 pCi/g + Background (Ra226, Th232)
  - ▶ UMTRCA goal is for residential use*
  - ▶ Background (95% UCL): 2.9 pCi/g
  - ▶ Derived Remediation Goal*: Ra-226 & Th-232: 7.9 pCi/g

* Use of UMTRCA residential remediation goal is conservative for West Lake, given land use restrictions that prevent residential use

What are Preliminary Remediation Goals (PRGs)?

- PRGs are used when first investigating a site to determine if additional investigation is needed (BMAC)
- Very conservative screening levels
- Follow the CERCLA acceptable risk range of excess cancer incidence rate of 1 in 1,000,000

Relative Risks for Comparison

- For comparison, some other lifetime risk factors
  - Death from heart disease ~ 1 in 6
  - Death from falls ~ 1 in 160
  - Death from storms ~ 1 in 30,000
  - Death from earthquake or landslide ~ 1 in 100,000
  - Death from lightning ~ 1 in 130,000
  - Death from food poisoning ~ 1 in 600,000
  - Death from accidental fireworks discharge ~ 1 in 650,000

* Source = National Center for Health Statistics 2008 Mortality Data

PRGs vs. RGs

PRGs

- Preliminary, not final
- Contaminant and media specific
- Risk based (generic scenarios)
- Usually do not consider
  - Site specifics
  - Technical Feasibility
  - Schedule
  - Resources
  - Costs
  - Regulations
  - Background
- Used as screening
- Very Conservative

RGs

- Final Remediation Goal
- Contaminant and media specific
- Must consider
  - Site Specifics
  - Technical Feasibility
  - Resources
  - Regulations (may not be risk based)
  - Risk
- Used to determine if site meets remedial action objectives

Summary

- Remediation Goals
  - ► Risk-based (site-specific calculations) or ARARs (regulations)
  - ► Remediation goals will be different from site to site
  - ► Background impacts
    - Background levels are ranges, not a single number
    - Vary from site to site

- Preliminary Remediation Goals
  - ► Screening only, used to determine if additional investigation is required
  - ► Intended to be very conservative

Summary

- What is a safe level of Radiation?
  - ► Radiation exposure occurs every day
  - ► Regulations conservatively based on assumption that any exposure to radiation results in some risk
  - ► Regulatory approach is to state in terms of "acceptable risk"
  - ► 1 in 10,000 chance of increased cancer risk is considered acceptable

- How is it determined if a site requires remediation?
  - ► Risk Assessment - who is exposed, what they are exposed to, how much they are exposed to, & how they are exposed
  - ► Risk Assessment results > 1 in 10,000 may require action

Questions?